Verified Level 3 Retrofit Technologies for Diesel School Buses

ARB Lower-Emission School Bus Workshops
October 14, 16, 20, 21, 22, 2008

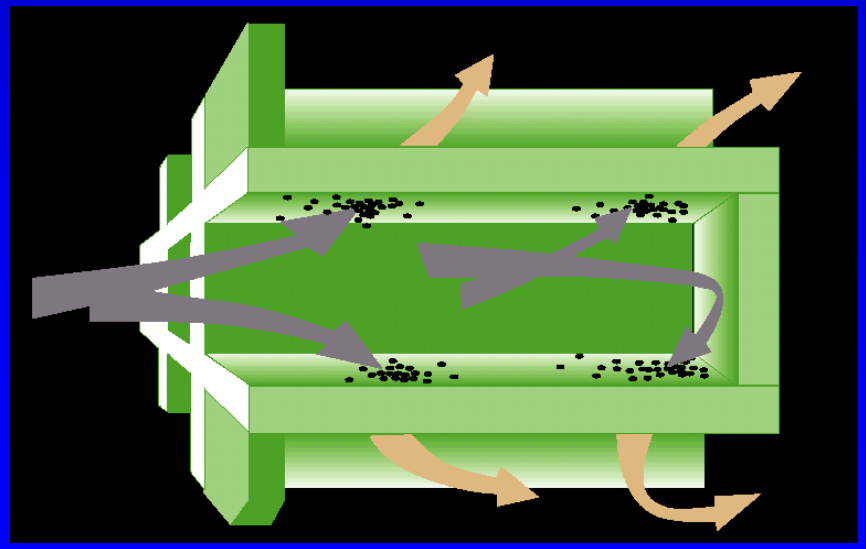
Manufacturers of Emission Controls Association (MECA)
www.meca.org
www.dieselretrofit.org

Strategies to Reduce Emissions from On-Road Diesel Engines

- Retrofit – installing a verified emission control device on an existing diesel engine
- Refuel
- Repair/Rebuild
- Repower
- Replace

Wall-Flow Diesel Particulate Filters Offer the Highest PM Filtration Efficiency

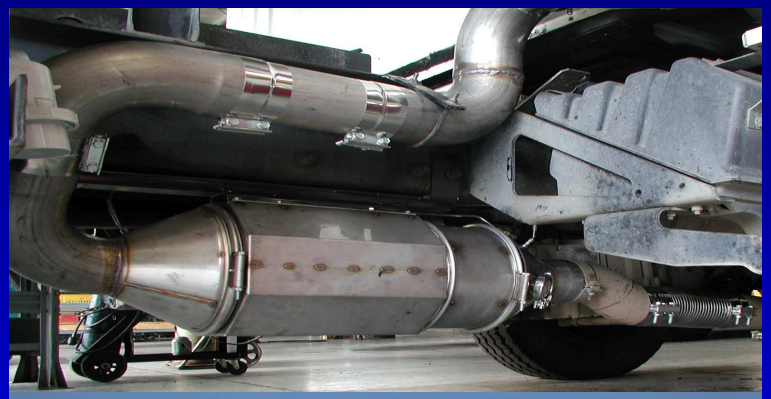
- >85% PM reduction (ARB Level 3)
- Large reduction in toxics from catalyzed DPFs
- >200,000 retrofits worldwide
- >5 million OE applications
- Same technology as on MY 2007 OE trucks and buses



Passive DPFs

- Passively regenerated DPFs employ a catalyst and available exhaust heat to burn captured soot
  - Specified exhaust temperature requirements (typically, 225-280 degrees C for at least 25% of driving cycle)
- Six Level 3 passive DPFs currently verified for school buses that meet CHP installation requirements

Active DPFs



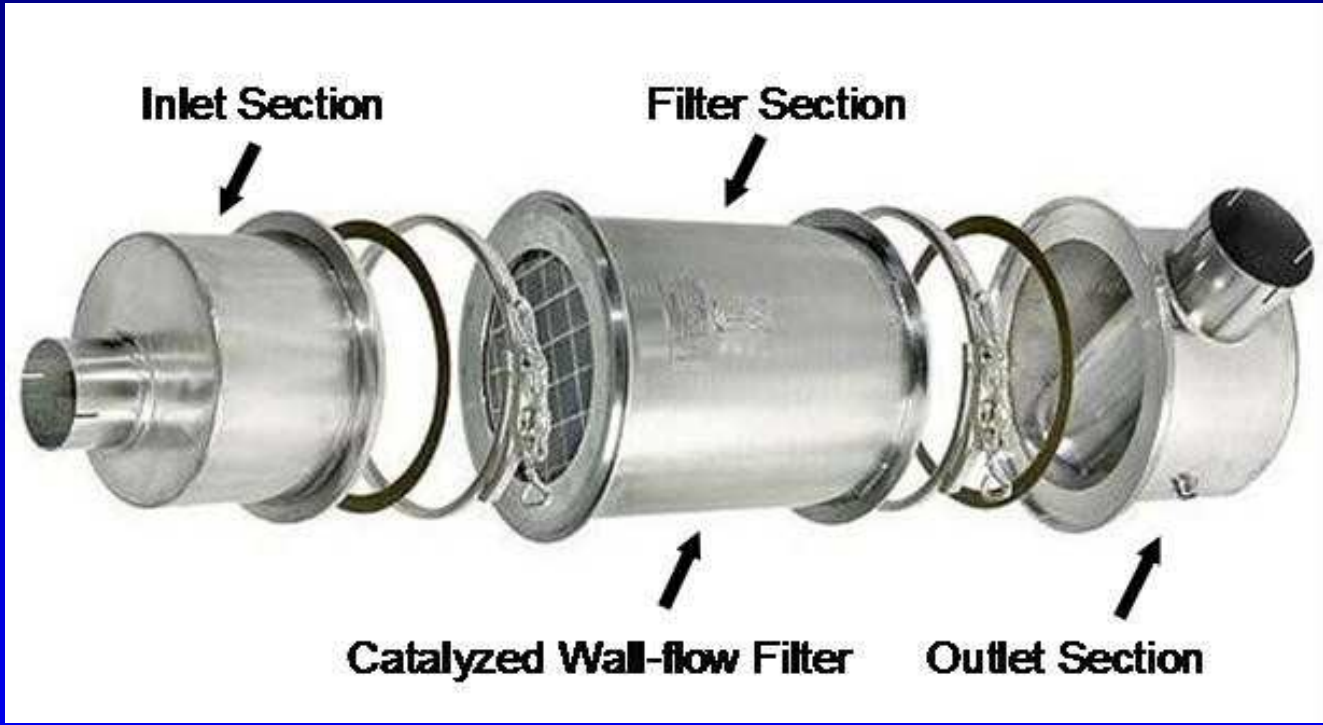
- Active regeneration uses a heat source such as an electrical heater, a flame-based burner, or a catalytic burner to combust the soot
- Suited for school buses with low exhaust temperatures
- One Level 3 active DPF currently verified for school buses that meets CHP installation requirements
  - Uncatalyzed wall-flow filter that uses electricity, through integrated heating element, to burn off soot

Application Engineering Needed to Determine Proper Retrofit

- Exhaust temperature/duty-cycle requirements
  - Match technology level to engine/vehicle operation
    - Duty cycle most important
    - Particular engine, ambient temperatures play smaller role
  - Determine data-logging need
    - Representative sample of engines
    - Coldest applications
      - Buses with short, slow, flat routes; high idle
  - Generate temperature profile using data-logger
  - Data analysis
- Make sure that engines selected for retrofit have been properly maintained prior to retrofit installation

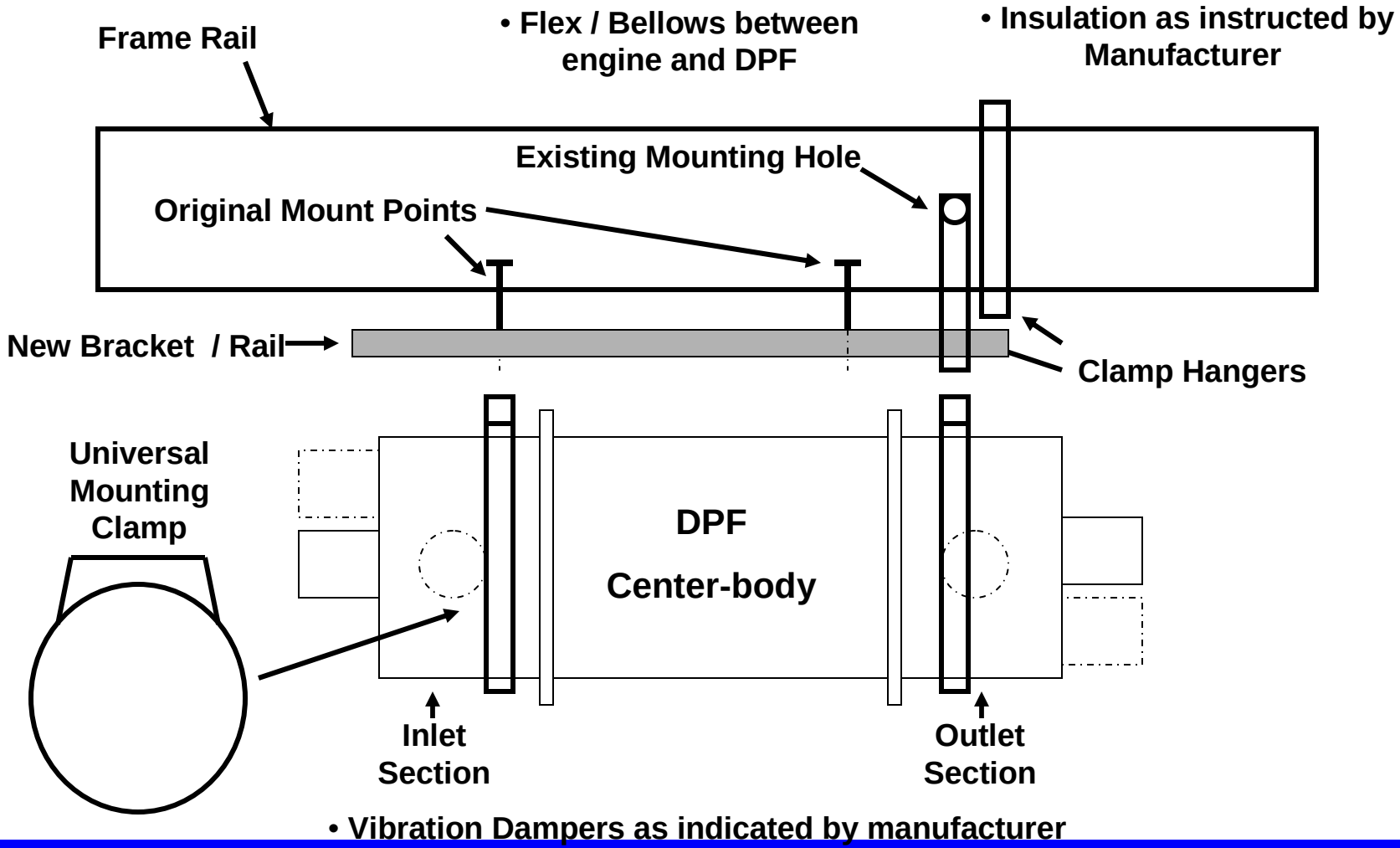
- ARB searchable database available on-line to assist end-users in matching verified retrofit devices with their particular diesel engine
  - www.arb.ca.gov/diesel/verdev/vdb/vdb.php

DPF Installation



- Most DPFs feature a generic design and removable filter centerbody for maintenance
  - DPF centerbody is heavy – proper support is vital
  - Inlet and outlet sections rotate to facilitate fit

Underchassis DPF Installation



DPF Installation on a School Bus

DPF Maintenance

- DPFs Require “Cleaning”
  - Regeneration: Carbonaceous PM (soot) collected in filter must be periodically combusted to avoid high backpressure or damage to filter
  - Ash Removal: Inorganic ash, which is not combustible, will collect in DPF over time and requires cleaning
    - Comes primarily from lubricating oil
    - Must be physically removed periodically

Ash Removal Is a Necessary DPF Maintenance Procedure

Captured in tail pipe . . .

Collected in filter bag . . .

Sealed in containers . . .

and sent to hazardous waste facility.

Proper Maintenance Important to Effectiveness of Retrofit Device

- Failure to clean a filter when necessary can potentially lead to:
  - Engine performance problems
  - Damage or destruction of the filter
  - Voiding the manufacturer's warranty
  - More complex and expensive ash removal processes
- Periodic inspections should include:
  - Warning lights from backpressure monitor
  - Mounting brackets and clamps
  - Presence of soot in tailpipe
  - Condensation in tubing associated with pressure sensors/monitors

On-Vehicle Monitoring for DPFs

- Backpressure and exhaust temperature monitor and alarm system
  - Backpressure monitor indicates when filter needs cleaning
- Data-logging to allow easy alarm diagnosis
- Resistant to environment
  - Typical aluminum enclosure allows installation on vehicle frame, inside engine space, or inside cab
- Easy-to-use software

Other Important Retrofit Issues

- Beginning January 1, 2009, a verified device may not increase baseline NO2 emissions by more than 20%
- Alternative diesel fuels and fuel additives not allowed for use with currently verified Level 3 technologies for school buses
- Currently verified Level 3 technologies for school buses are generally compatible with biodiesel
  - Typically, B20 or less (biodiesel blend needs to meet current ASTM specifications)

Currently Verified Level 3 Retrofit Technologies for School Buses (October 2008)

- Cleaire Horizon
  - Active DPF, 2009 NO2 compliant, verified for B20 or less
- Donaldson DPM
  - Passive DPF, verified for B20 or less
- Engine Control Systems Purifilter (Low Load)
  - Passive DPF, 2009 NO2 compliant, verified for B20 or less
- Engine Control Systems Purifilter (High Load)
  - Passive DPF, 2009 NO2 compliant, verified for B20 or less
- International DPX
  - Passive DPF, verified for B20 or less
- Johnson Matthey Reformulated CRT
  - Passive DPF, verified for B20 or less
- Johnson Matthey EGRT
  - Passive DPF, 2009 NO2 compliant

- Current list of verified diesel emission control strategies:
  - www.arb.ca.gov/diesel/verdev/vt/cvt.htm

Significant Experience around the U.S. with School Bus Retrofits

- Over 3,800 school buses in California already retrofit through Lower-Emission School Bus Program
- Other school bus retrofit programs around the U.S.:
  - Puget Sound Clean Air Agency Diesel Solutions Program
  - Texas Clean School Bus Program
  - MassCleanDiesel
  - New Jersey DEP Mandatory Diesel Retrofit Program
  - Ohio EPA Clean Diesel School Bus Fund
  - Georgia Adopt-a-School Bus Program
  - Pittsburgh Healthy School Bus Fund
  - Clean Buses for Kids (Toyota settlement)
- EPA FY08 Funding for National Clean Diesel Campaign
- Number of DPF retrofits on school buses growing

Summary

- DPFs provide a cost-effective option for cleaning up PM emissions from in-use school buses
- Seven Level 3 retrofit devices have been verified by ARB for school buses that meet CHP installation requirements (as of October 2008)
- Application engineering is a necessary step to matching a school bus diesel engine with the correct retrofit solution
- Proper maintenance important to long-term effectiveness of retrofit device
- Significant experience with retrofit technologies exists around the U.S. for school buses; DPF retrofit experience is growing

Successful Retrofits Require a Cooperative Effort Between School Bus Fleet Managers, Bus Drivers, and Technology Providers

www.dieselretrofit.org